BULLETIN

OF THE

SOUTH DAKOTA SCHOOL OF MINES.

NOTES ON THE
GEOLOGY AND MINERAL DEPOSITS
OF A PORTION OF THE
SOUTHERN BLACK HILLS.

RAPID CITY, SOUTH DAKOTA,
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GENERAL GEOLOGY.

BY CLEOPHAS C. O'HARRA.

Introductory.

It is the established custom of the State School of Mines to provide means for the field study of various geological, mineralogical and mining problems relating to the state. In accordance with this custom, a few weeks were spent by the school survey party in the Southern Black Hills during the past summer. The party for a portion of the time numbered six, including professors and students.* In so far as convenient, the work was carried on with the view of training the students of the party in the methods best adapted to the study of field geology. Every effort, however, was put forth in order that new facts might be gained which would aid in unravelling the geological history and the economic possibilities of the region.

It was with this latter idea definitely in view that our party selected for examination that portion of the pre-Cambrian rocks of the Southern Hills, which lies in the north central part of Custer county, southeast of Harney peak. More definitely, the particular area to which most of our attention was directed, may be described as bounded on the north by a line corresponding approximately with latitude 43° 50′, which crosses

*The author of this paper wishes to make particular acknowledgment to Professor McLaury for assistance rendered in connection with the field work.

the head-waters of Iron creek and Spokane creek (sometimes known as Little Squaw creek), on the east by the Cambrian quartzite,* on the south by French creek, and on the west by the meridian of 103° 30′ west longitude. The survey camp was situated in the west central part of the area seven miles N. 80° E. of Custer, and eight and one-half miles S. 12° W. of Keystone. In addition to the study in this area, several neighboring localities of especial interest were also visited.

The position of the area, with reference to the general Black Hills region, may be seen in the accompanying sketch map, figure 1.

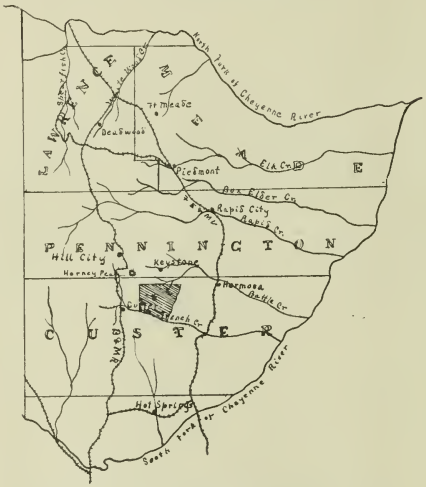

FIGURE 1. SKETCH MAP SHOWING LOCATION OF AREA SURVEYED.

It is well known that of the large amount of valuable mineral products now obtained in the Black Hills, by far the larger part comes from the Northern Hills. This is particularly true of gold. The Southern Hills have hitherto produced only a comparatively small amount. However, diligent prospecting has revealed the fact that rich gold ore exists there in areas of considerable extent and in one or more places, extremely handsome returns are now being realized. Little or no detailed scientific work has hitherto been carried on for the purpose of solving the economic problems of the gold-bearing rocks in the restricted area to be discussed in this paper. Our party has endeavored to supply, as best it could, the want in this direction.

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*This is the so-called Potsdam of the Black Hills. During the time at our disposal only the general position of this contact line could be mapped.

Topography.

Topographically the region is sharply separated into two divisions. A rather prominent but somewhat irregular line of ridges beginning a short distance west of Spokane and running in a general southwesterly direction marks the line of separation, (see the geological map, figure 4). The area to the west is occupied by granites, schists, and quartzites, the granite greatly predominating. East of the line of separation and including the line of ridges mentioned, the rocks are also granites, schists and quartzites, but, unlike the western area, the prevailing rocks here are quartzites. This diversity in rock character is the chief cause of the marked difference in topographic features.

The western topographic area is, in general, extremely rough and difficult to traverse. The granite is exposed in numerous mountain peaks, serrated ridges, slender pinnacles, sharp needles, and lenticular masses projecting frequently to considerable heights above the general surface. Newton, in the Geology of the Black Hills* has described to some extent the general surface features of the granite district but no one can fully appreciate his graphic description of the delays and hardships encountered by his party in their attempt to reach Harney peak until he himself has tried to follow a direct course for several miles over this extremely rough granite surface. Here and there a small park is found which, when cleared of forest and properly irrigated, furnishes a fruitful field and a comfortable home for the careful ranchman. The numerous little angular valleys and small parks, as well as the high rounded shoulders of the larger peaks are generally covered by a considerable growth of pine trees, which conceal from the distant observer all but the clean precipitous sides of the higher granite masses, and thus add a pleasant charm to this most beautiful mountain scenery.

* Report on the Geology and Resources of the Black Hills of Dakota, with atlas. By Henry Newton, E. M., and Walter P. Jenney, E. M., Washington, 1880.

Figure 2 shows the granite area as seen from the top of Saddleback ridge looking toward Harney peak.

The surface of the eastern topographic area, although in many places quite rough and showing narrow ravines, deep gulches and precipitous canyons, has little or none of that rough jagged appearance of the granite area. Here the surface is undulating and the hillsides are generally covered by a heavy soil and a dense timber growth to the very top. Sharply rounded hills and narrow-crested, irregularly curving ridges separ ated by deep winding valleys are the rule. Figure 3 shows the surface features of this region as seen from near the top of Chilkoot hill, looking southward toward Sheep mountain.

Drainage.

Battle creek and French creek drain the area, their waters flowing eastward into the prairie region and finally emptying into the south fork of the Cheyenne river. Of these, French creek, which in this part of the Hills is considerably the stronger of the two streams, drains only a small portion of the area, the divide being situated within two or three miles of the creek. Several small branches carry the water from the remainder of the area in a general northeasterly direction to Battle creek. Among these smaller streams are Iron creek, which joins Battle creek near Hayward and Squaw creek which flows into Battle creek two miles southwest of Hermosa. Squaw creek itself receives water from several smaller streams of some importance, the local names for which are Spokane creek (Little Squaw creek), Bear gulch, Middle Squaw creek and South Squaw creek. Some of these streams in various parts of their courses have cut deep gorges or canyons and throughout the upper part of their courses the descent is rapid. In their lower courses the current is less swift and in several cases the water sinks beneath the surface and disappears so that throughout much of the year this part of the stream bed is dry. Furthermore, on account of the deficiency of rainfall, many of the smaller stream beds, in the

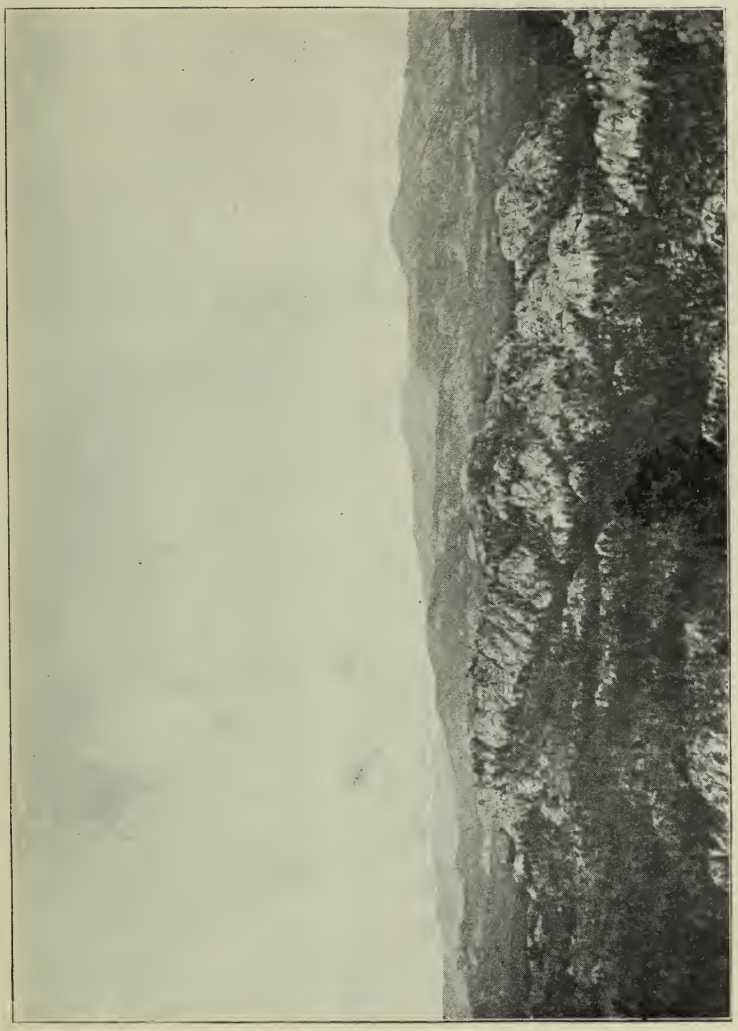

FIGURE 2. GRANITE AREA AS SEEN FROM SADDLEBACK RIDGE. HARNEY PEAK IN THE DISTANCE.

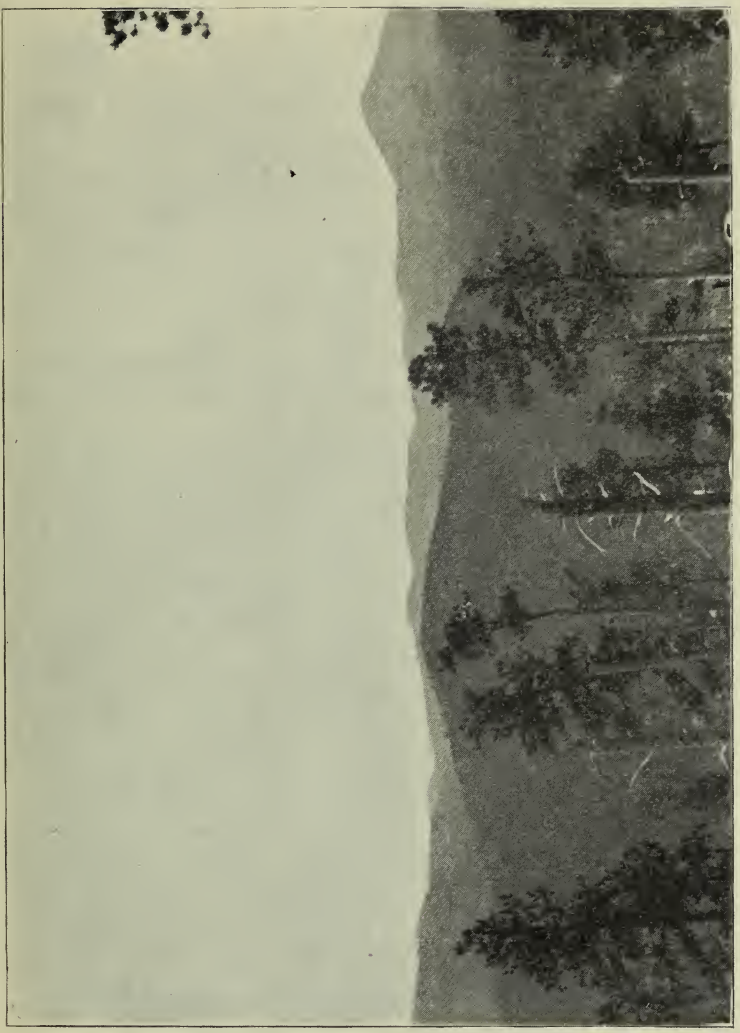

FIGURE 3. QUARTZITE AREA AS SEEN FROM NEAR THE TOP OF CHILKOOT HILL. SHEEP MOUNTAIN IN THE DISTANCE.

more elevated portions of the area, are wholly dry throughout much of the year.

Altitude.

The highest point in the area is Sheep mountain, near French creek, which reaches a height of 6050 feet above sea level.* North of this point the height over a considerable portion of the area is more than 5500 feet, and in the northwestern part one or two isolated granite peaks closely rival Sheep mountain in height. The lowest point is about 4000 feet, which altitude is reached along some of the creek beds near the eastern border of the area. For the whole area, the average elevation is perhaps not far from 5300 feet.

Geology.

As previously stated, the rocks of the area are granites, quartzites and schists (see figure 4). Granites

Figure 4. Geological map. Topography reduced from Hermosa sheet, U. S. G. S., 1894.

* Hermosa sheet, U. S. G. S., 1894.

prevail in the western part, quartzites in the eastern. Schists are common to both. In this paper, we shall include all of these rocks under the name Pre-Cambrian, the authority for this being based on conclusive evidence. Newton, in discussing the age of the granite, says, in reference to the section along French creek, "A continuous sheet of Potsdam passes from a surface of eroded schist to a surface of granite. There was found no intrusion of the granite along the parting between the Potsdam and the schists and there was found no metamorphism of the Potsdam at the surface of contact with the granite.* Similar phenomena as well as additional evidence were found by Professor Headden in the vicinity of Hayward on Battle creek.† In several places examined by us between these sections, the evidence is as unmistakable. Figure 5 gives a view of the Cambrian quartzite, as shown on Squaw creek at the north side of the county road, one mile east of Otis. Here the Cambrian quartzite, the lowest part of which is frequently coarsely conglomerate, lies directly upon a medium coarse granite. Two exposures of the granite are shown in the plate, the largest one disclosing the contact line for a distance of twenty feet or more. The overlying Cambrian quartzite is wholly unchanged so far as affected by the presence of the granite.

Figure 6 shows a similar contact exposed on the north bank of Dry creek, two hundred yards north of the Custer-Fairburn road, a little more than a mile south-southeast of Otis. Here, however, the underlying coarse granite is present only in the form of clearly defined dikes which, having broken through the pre-Cambrian quartzite, extend upward to the Cambrian quartzite, where they are sharply truncated on a level with the eroded surface of the pre-Cambrian, which is unconformably overlain by the Cambrian quartzite. The

* Geology of the Black Hills of Dakota, p. 78.

† Van Hise, C. R. The Pre-Cambrian Rock of the Black Hills, Bull, G. S. A., Vol. I, p. 212, Washington, 1890.

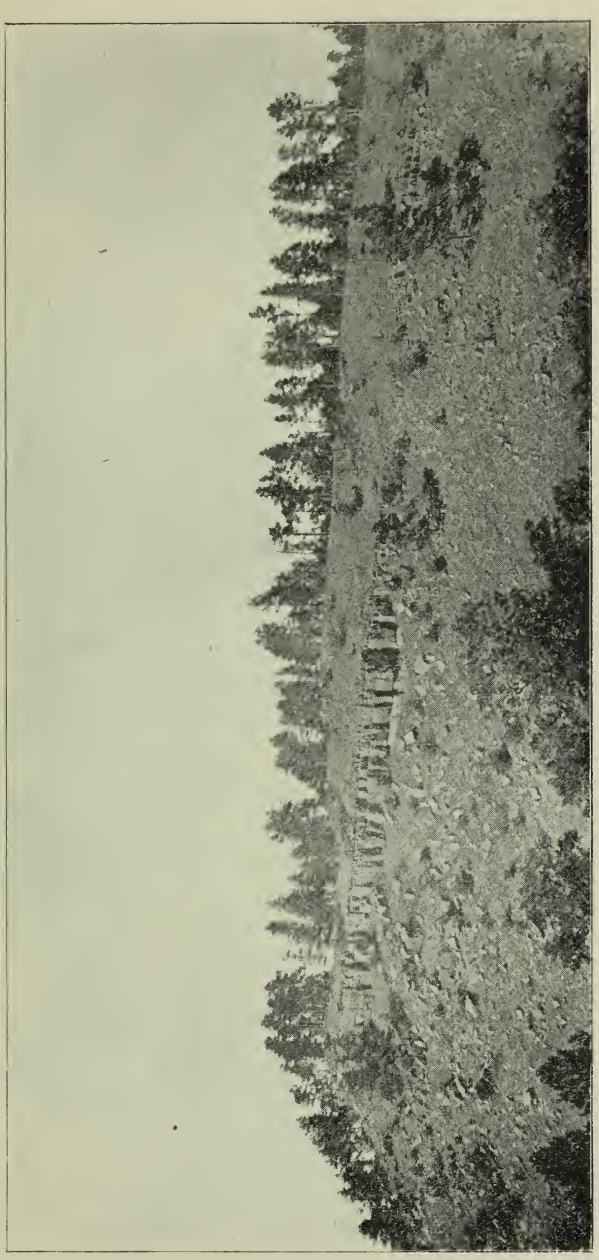

FIGURE 5. CAMBRIAN—PRE-CAMBRIAN CONTACT NEAR OTIS.

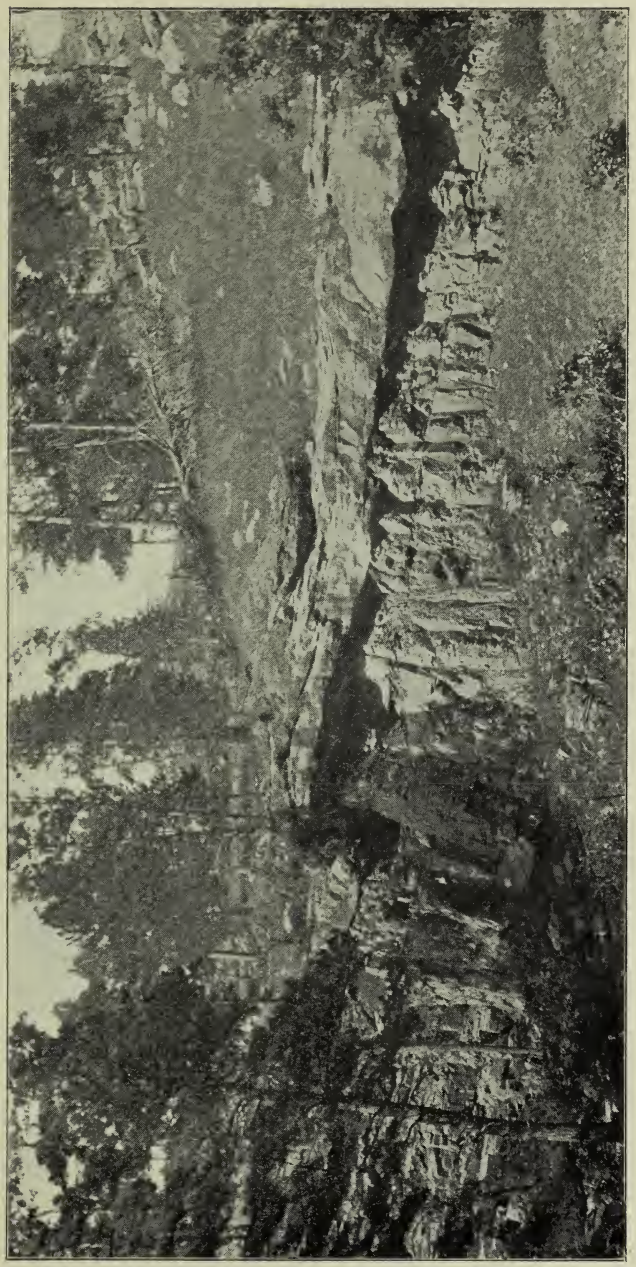

FIGURE 6. CAMBRIAN—PRE-CAMBRIAN CONTACT ON DRY CREEK.

dikes shown in the plate are pegmatitic in character, and are four in number. The one farthest east is ten inches thick, the next two inches, the third fourteen inches, and the fourth, the one farthest west, beneath the opening, is six feet.

Granite.—The granite is much the same in general character throughout the entire area. It is made up of white or pinkish feldspar, clear, smoky or rose quartz, and light or dark mica, besides numerous accessory minerals. Among the latter, tourmaline is particularly abundant. The percentage of feldspar is high. According to Newton, the Black Hills granite as a whole is made up of about 70 or 75 per cent of feldspar, 20 per cent of quartz and 5 per cent of mica.* The texture varies within rather wide limits but it is in general very coarse. Medium grained granite is not uncommon over considerable areas, but the finer varieties are almost wholly lacking. Much of the rock is made up of very large crystals and frequently instead of the several minerals being uniformly distributed throughout the mass each one is arranged in extremely irregular segregations. This prominent coarse nature of the crystals together with other phenomena has given rise to various views concerning the origin of the granite.† We shall make no attempt in the present paper to enter into the discussion of this question.

The granite does not represent a continuous phase of development. Over considerable areas the coarser granite, which among the prospectors and miners is known as "bull rock," appears to have no regularity of arrangement. More frequently the coarser portions run through the medium grained granite in the form of irregular streaks without any well marked line of sep-

* Geology of the Black Hills of Dakota, p. 70.

† Newton, Henry. Geology of the Black Hills of Dakota, 1880.
Carpenter, Franklin R. Notes on the Geology of the Black Hills. Preliminary Report of the Dakota School of Mines, 1888.
Crosby, W. O. Geology of the Black Hills of Dakota, 1888.
Van Hise, C. R. The Pre-Cambrian Rock of the Black Hills, 1890.

aration. In many places, however, the coarser material, which is pegmatitic in character and frequently partakes of the nature of graphic granite, is observed in distinct dikes, they being oftentimes found cutting through the body of medium grained granite as clearly and sharply defined as if outlined with a pencil. This feature is confined to no particular portion of the area studied, but it was found perhaps best developed south of Middle Squaw creek, about two miles north-northwest of Sheep mountain. Apparently many of the dikes, the outlines of which are irregular or obscure, are really formed in the same way as the more clearly defined dikes but unequal weathering of the general rock surface has in the case of the former obliterated that which would be clearly shown in a smooth cross section.

In many of the better defined dikes the texture at the edge is finer than toward the center, and not infrequently the crystals are arranged uniformly perpendicular to the wall of the dike. This feature is particularly prominent in the case of tourmaline when abundant crystals of this mineral occur in the narrower dikes. It is well known that the main masses of granite, which are generally lenticular in shape, run nearly parallel with the strike of the schists and quartzites as first pointed out by Newton.* The smaller dikes cut these in various directions.

Owing to the possible influence which they may have upon the economic development of the area, considerable attention was given to the study of the direction in which the dikes run. The results show that a large proportion of them extend radially toward Harney peak, but there seems so many exceptions that the observations are probably of little value.

Ordinarily the dikes wherever well exposed, whether in granite or in quartzite, weather more rapidly than the main mass of rock so that the position and direction of the dikes may be readily traced. This is par-

* Geology of the Black Hills of Dakota, p. 73.

ticularly true when the dikes cut through fine grained granite or quartzite. Here the coarse crystals easily disintegrate and shrubs and small trees quickly spring up to mark the line of rapid weathering. On the other hand, the dikes, when cutting through schistose rocks, are found generally to be less easily distintegrated than the schist, and therefore project above the general surface.

Metamorphic Rocks.—These include the schists and quartzites which are found intimately associated in varying quantity throughout the region studied, but which predominate only in the southern and eastern portions. They do not make up the entire rock mass over any extensive well defined area, granite being always present in greater or less amount in the form of dikes or irregular masses.

In the accompanying geological map an attempt has been made to indicate the relative proportions of the metamorphic rocks and the granite. The larger and more important areas are located and defined with some degree of accuracy but no effort has been made to reproduce in detail the intricate relations of the various rock-masses throughout the entire area. This was wholly incompatible with the time at our disposal, and, owing to the many difficulties to be encountered, could at best lead only to questionable results. For the distribution of the rocks in the immediate vicinity of our camp the reader is referred to the accompanying paper by Professor Forsyth.

In places, the original bedding of the metamorphic rocks is still discernible. An example of this may he seen at the roadside one-half mile west of Otis. A photograph of this out-crop, through which runs a dike of pegmatite is shown in figure 7. Areas in which quartzites abound are usually indicated by ridges. This feature is particularly prominent in the case of Spokane ridge, Saddleback ridge, and Sheep mountain, and is quite noticeable, although less pronounced, in many of the lower ridges and hills to the east. Localities occupied chiefly by schists are represented by valleys.

Owing, however, to the fact that the granite is also inclined to weather more rapidly than the heavy quartzite the schistose valleys are not so typical as are the quartzite ridges.

The schistose rocks are made up chiefly of quartz, biotite and feldspar, although in some restricted areas hornblende or garnet is a prominent constituent. Tourmaline is sometimes present, although never in abundance, and graphite is occasionally found. Muscovite sometimes takes the place of the biotite, and not infrequently these two minerals occur together. Biotite is, however, much the more common of the two minerals. The schists in which hornblende is the chief constituent are found in considerable abundance west, northwest and southwest of Otis. These appear to be highly metamorphosed basic igneous rocks, are sometimes gold-bearing,* and probably come within the class designated by Professor Van Hise as dioritic rocks which have partaken of the alteration effects of the forces that metamorphosed the fragmental series.† In color, they are very dark green, almost black, and wherever seen are inclined to be rather massive.

In the micaceous schists the biotite is present as medium brownish black flakes, pretty evenly distributed among the quartz granules. These flakes have in the main originated as a secondary product through the alteration of the original feldspar.‡ The feldspar is not particularly prominent in any case but the biotite and the quartz vary widely in amount present, the specimens collected showing almost all gradations from a highly crinkled, very dark, nearly quartzless schist, to a massive, even grained, translucent quartzite.

The quartzites vary little in character, except at times they show by the presence and regular arrangement of mica or feldspar an approach to schistose conditions. They are usually compact and homogeneous,

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* Carpenter, F. R. Notes on the Geology of the Black Hills, p. 25, 1888.

† The Pre-Cambrian Rock of the Black Hills, p. 230, 1890.

‡ Ibid, p. 223.

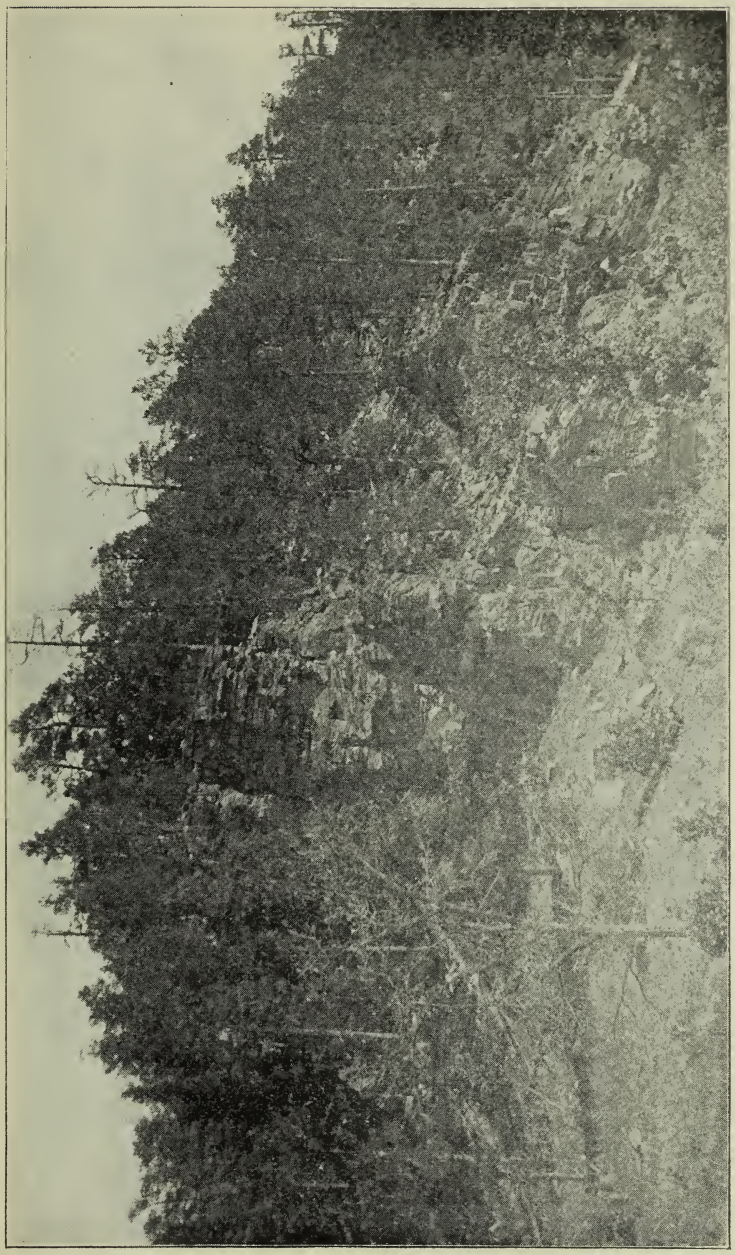

FIGURE 7. QUARTZITE EXPOSURE NEAR OTIS. PEGMATITE DIKE IN LOWER PART.

the purer varieties showing quartz as almost the only constituent. Clear, almost colorless, varieties are not uncommon but more often, owing to impurities, some shade of blue, green or red is noticeable.

Quartz veins varying in size from a mere line up to as much as fifty feet or more in thickness occur abundantly throughout the areas covered by the schists and quartzites. Many of these veins are gold-bearing and it is for this reason that their study has become of importance. Particular attention was paid to the relative age of these veins. They cut both quartzites and schists in every direction, hence the quartz veins are younger than these rocks. So far as could be learned, the hornblendic schists are not excepted, they being traversed by the veins in all cases in the same manner as are the micaceous schists. The quartz veins, however, are in turn cut by the pegmatite dikes so that at every place where observation was made, the veins proved to be older than the dikes. The importance which this feature may seem to have upon the economic development of the gold-bearing veins is discussed by Professor Forsyth in the accompanying paper of this bulletin. In some places, quartz veins were found traversing the main body of granite but these veins were nowhere prominent and in general they do not appear to be contemporaneous with nor similar to the gold-bearing veins.

The strike of the schists and quartzites is considerably east of north. In many exposures this is not easily made out, owing to the disturbing influences of the granite, but the ridges formed by the hard quartzite beds frequently indicate the direction with considerable accuracy. Spokane ridge and Saddleback ridge whose general direction is about N 35° E seem to follow the strike pretty closely.

Effort was made to determine the position and nature of folds if present. None of importance were located, the various disturbances having apparently obliterated the characteristic features of such folds as may have existed. Westerly dips were occasionally found, but in most cases observed the dip is to the east.

Joint planes, as might be expected, are well developed. The numerous heavy quartzite talus slopes throughout the area are largely made up of the rhombic blocks produced by these joint planes. In the granite areas these planes, although less abundant, have greatly aided weathering and it is to this fact that numerous rocking stones and many of the picturesque needle-like projections are due. As previously suggested the pegmatite dikes so common in many parts of the granite region weather more readily than the even grained granite which the dikes traverse and these may be observed in some places to have weathered out forming narrow crevices extending several feet below the general level of the granite mass thus simulating the effect of the joint planes. The granite only rarely produces talus slopes of joint blocks the fragments collected at the base of the cliffs being almost always fine and angular, forming a kind of granite gravel easily removed by erosive agents.

Irregular fragments of quartzite and schist imbedded as foreign bodies in the granite are of frequent occurrence. These masses, which in the miner's language may be termed "horses" are of all sizes up to many feet or yards in diameter.

Figure 8 shows one of these enclosed bodies exposed at the top of Saddleback ridge about one mile north of Little Squaw creek. The much jointed rock is the quartzite.

History.

The probable early geological history of the Southern Hills is briefly as follows: In Algonkian time the schists and quartzites were deposited as sediments derived from land lying apparently either to the west or to the northeast of the position now occupied by the Hills. Later, these original sediments were cut by basic eruptives at which time more or less metamorphism and folding were produced. Subsequent to this action the clastic rocks as well as the basic eruptives were ramified by quartz veins many of which are gold-

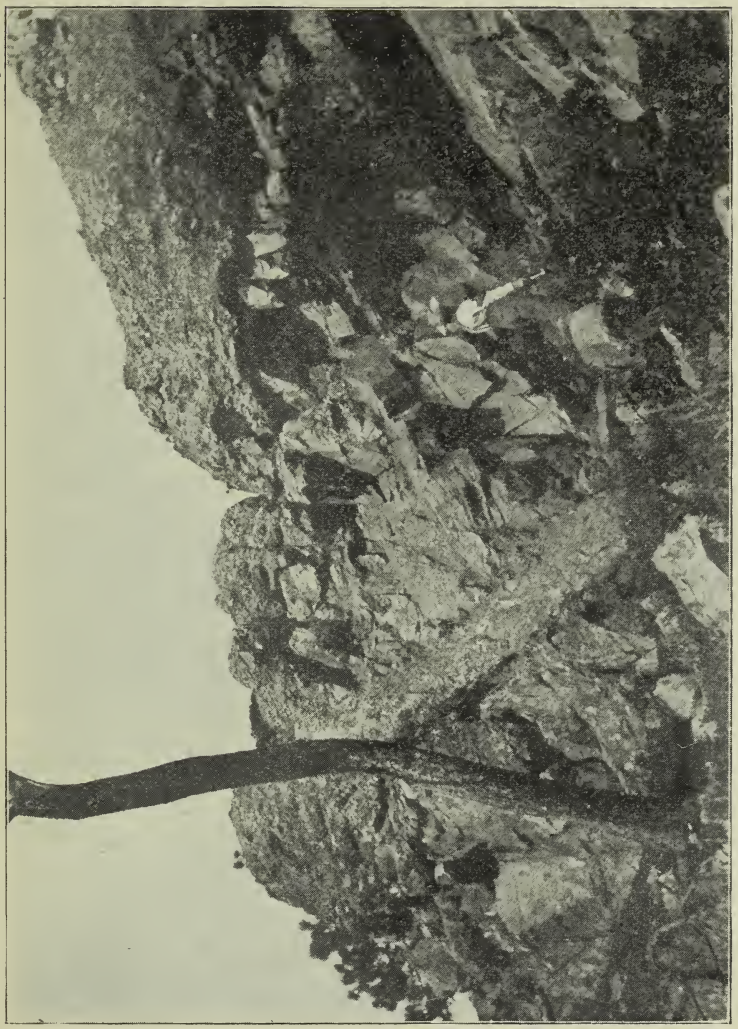

FIGURE 8. QUARTZITE ENCLOSED BY GRANITE.

bearing. Following* the eruption of the basic rocks and after most or all of the gold-bearing quartz veins were formed, extensive granite intrusions occurred. Apparently at the time of the intrusion of the basic eruptives the slaty cleavage was produced and approximately coincident with the granite intrusions, the crystalline schists and the schistose structure, so prominent in many parts of the Hills, was developed.† At some time during the middle or latter part of the Algonkian period the sea shallowed, and the land rising above the sea as an island, reached a considerable height. The rocks thus brought under the influence of erosive agents supplied the sediments which make up the Cambrian rocks surrounding the Hills.

Note.

Through the kindness of Messrs. A. Madill and William McGarrity, of Glendale, two members of the party were able to visit the placer mines at Hayward immediately after breaking camp. While there our attention was directed to a tunnel which had been driven several years ago into a hill on the south side of Battle creek, near the placer workings, a short distance west of town. The tunnel, which is known as the Broken Hill mine, is almost immediately beneath the Cambrian quartzite, and has penetrated very dark pyritous schist for a distance of perhaps a hundred feet. Near the entrance and extending back to the end of the tunnel, melanterite was found in considerable abundance, it having been formed in the presence of decomposing pyrite. So far as can be learned, melanterite has not hitherto been described as being found in the Hills, and as the beauty, freshness and quantity of the material is rather out of the ordinary, we deem it of sufficient importance to those interested in the mineralogy of the Black Hills to make mention of it here.

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* Todd, J. E. A Preliminary Report on the Geology of South Dakota, p. 134, Sioux Falls, 1894.

† Van Hise, C. R. The Pre-Cambian Rock of the Black Hills, p. 241, 1890.

The specimens of fresh material collected have a rich green color, and partake more or less of a fibrous nature. The partially dehydrated material is glossy white, and shows a prominent asbestiform structure. Fresh specimens quickly change to this condition, unless special care be taken to prevent it. The mineral, in a more decomposed state sometimes, although rarely, shows a slight yellowish tinge, and readily crumbles in the hand. Good crystals were not found.

The mineral occurs in stringers, sometimes two inches or more in thickness, which ramify the pyritous schist in various directions. The remarkable feature in connection with the deposit is, that delicately balanced conditions should prevail at or near the surface for a considerable length of time sufficiently stable to allow the formation of an easily soluble mineral in such abundance as is the melanterite at this place.

The chemical composition of the melanterite is peculiar. The percentage of ferrous sulphate is quite low. Potassium sulphate is present in considerable quantity, and free sulphuric acid is particularly prominent. The amount of water is also very high. Apparently the excellent preservation of the material is in considerable measure due to the presence of the free sulphuric acid. In the analysis which has been made no opportunity was given for the careful selection of fresh material, hence the exact results thus far obtained need not be given until other analysis are made.*

A minutely crystalized brownish or wine-colored mineral occurs in very small quantity with the melanterite. This mineral is also an iron sulphate. The general characters of the mineral indicate that it is amarantite, although positive evidence of this has not yet been definitely established.

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*The author is indebted to Mr. M. N. Bolles and Mr. L. M. French, students in the School of Mines, for the analytical work.

MINING GEOLOGY AND MINING.

BY A. FORSYTH.

I. Introductory.

The object of this survey was twofold; first, to study geologically in the interest of mining and of pure science, a selected portion of the Black Hills; and second, to give to students of the School of Mines practical geological and topographical work in the field. This twofold object was, it is thought, in considerable measure attained.

The work of the students consisted mainly in making a careful topographical and geological map of a gold mining district. The work of the instructor was that of directing and assisting them, of studying with them, and of making notes and observations on mineral deposits at various points outside the area surveyed.

II. Chilkoot Gold Mining Region.

Area Surveyed.—The black square within the cross-hatched area on the map, Figure 1, of the preceding paper, and also the triangle marked "Survey Camp" on the map, Figure 4 of the same paper, show the location of the region surveyed. It comprises about three-quarters of a square mile, and covers the more important gold quartz claims and prospect openings. On page 31 is the completed geological and topographical map.

This selected area gains interest from its newness and from some peculiar features of the occurrence of gold. There is the interest of studying future possibilities, of balancing the indications for and against future successful development.

The surface features of the country are pleasant and promising. The map shows portions of three hills. They are of the gracefully rounded shape characteristic of the quartzite ridges of the vicinity. They rise about 300 feet from the bottoms of the intervening val-

leys. The country is clothed with the heavy pine covering of the Southern Hills. Trees of two feet and more in diameter are abundant. Pine is practically the only tree found. The spruces of the Custer region are conspicuously absent. The timber is protected by the laws governing the Forest Reserve. Water is found both north and south of the area mapped. On the north is Big Squaw creek; on the south, Middle Squaw creek. These creeks with their tributary springs carry the clear cold water characteristic of the Algonkian area of the Hills.

Prospecting.—The first quartz locations in this vicinity were made in 1893. Previous to this there had been some placer exploration in the bottom of the gulches. With what success, it is not known. The claims located in 1893, were the Parrish, the Chilkoot and the Detroit, (map, p. 33.) In prospecting, the first ore sought was a quartzite, distinctive by a yellowish green cast. It was found to contain small gold values, ($1.00 to $2.00 per ton). The Parrish was located on this material, but further search for green rock disclosed to the prospectors white quartz veins of greater value. On such were staked the Chilkoot and Detroit. These veins range in width from one inch to two feet, and are credited with gold values of from $20.00 to $80.00 per ton, with rich spots running much higher. Much of the gold is free as shown by the pan tests.

The Rocks.—The rocks are members of the Algonkian system of the Hills*. Quartzite has already been mentioned as constituting the ore first sought. Besides this, there occur in the area mapped, mica schist, granite with a pegmatitic variation, and the quartz gold veins.

In age, from oldest to youngest, the order becomes:

1. Quartzite.
(1 a). Mica Schist.
2. Quartz veins.
3. Granite. (Pegmatite.)

* See Dr. O'Harra's paper, p. 24.

The quartzite is hard, close grained, white in general appearance, but carrying in small grains a fair percentage of ferruginous matter.

Mica schist plays a very unimportant part in the small area under consideration. It occurs in several openings plainly as the result of dynamic metamorphism produced at the time of the shattering of the quartzite. On this evidence it gains its order, (1 a). This order is however provisional and may apply only to the small occurrence here considered. Two or three inches was the greatest thickness of schist observed. More extensive schistose masses occur not far outside the boundaries of the map. These however, cannot be here discussed.

The auriferous quartz veins cut quartzite but not granite. Figure 9 gives an example of the relations of quartzite, auriferous vein quartz, and granite. This sketch is of the Detroit opening. It is the type of several exposures in the vicinity. The relative age of granite and gold quartz here shown is most important to the prospector and miner. It naturally means that they must take into consideration chances of profitable veins being cut off by granite sheets and must calculate on the thickness and frequency of these sheets.

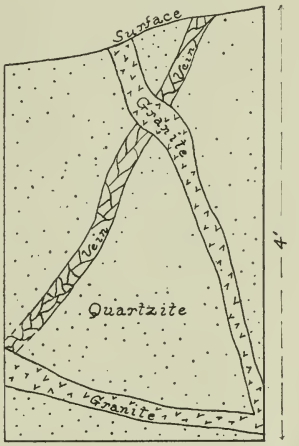


FIGURE 9. SHOWING RELATIONS OF QUARTZITE, GOLD QUARTZ AND GRANITE.

The gold quartz is clear, white and glassy. Characteristic of it are numerous small cavities 1-32 of a inch and less in diameter, containing little graphite crystals. In places there is much iron stain, possibly from pyrite oxidation. Pyrite unaltered does not yet appear in the present early stage of development. The gold occurs in very finely divided condition, usually more abundant in the iron stained portion.

The granite is that of the Harney Peak area. Fre-

quently it is pegmatitic in character. In fact it is an open question if all the granite in this region had not better be called pegmatite.*

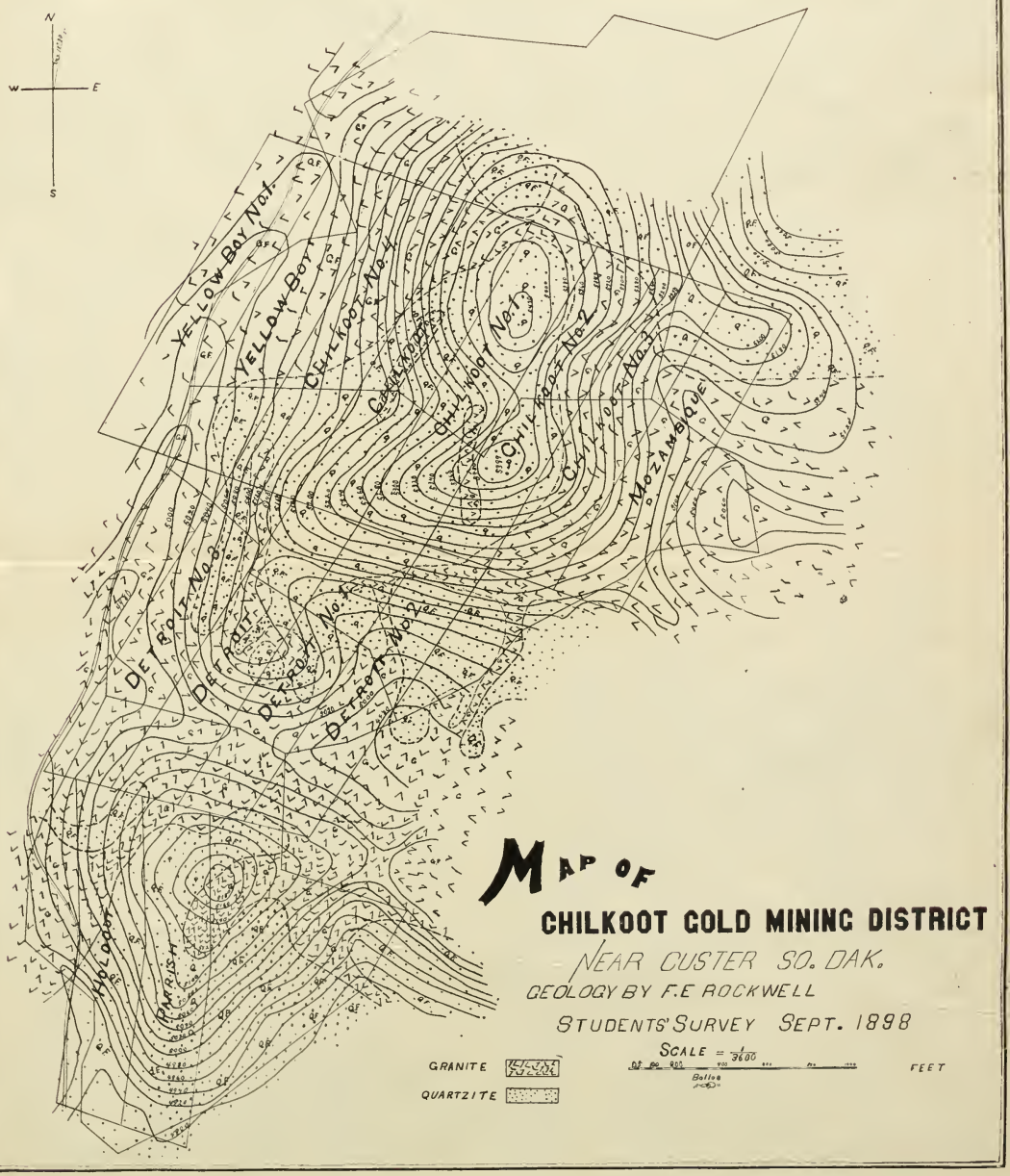
Attitudes of Granite and Quartzite.—The shape of the granite masses and the relative proportions of granite to quartzite present most important problems.

The map, page 33, gives proportions by area of granite to quartzite. From this map also are seen two apparent systems of quartzite fissures now occupied by the granite masses. There is an east-west system shown most plainly along the southern end of the Detroit claims and a north-south system branching from this and appearing also in isolated granite patches on other parts of the map.

That all the fissures of these systems are vertical, is not assumed. On the contrary there is much evidence of flat lying granite throughout the area. Above the road, near the southwest corner of the map, is a cliff exposure with granite and quartzite in horizontal layers. Near the eastern edge of the map at the end of the Mozambique claim are signs of flat granite. Here appear some large quartzite horses flat-lying, and evidently but little displaced. Again on the Chilkoot claim, a tunnel to the vein is driven under a granite roof. A winze sunk a few feet below the tunnel level cuts still another horizontal granite layer. In an opening on the Parrish, both horizontal and vertical granite may be seen. Horizontal sheets of an inch and less in thickness here are plainly branches from a large vertical mass. The thickness of these horizontal masses where they can be plainly observed is from two feet down to less than one inch. It is most probable that in places they are much over two feet in thickness.

Closely connected with the attitude of the granite masses is the attitude of the enclosing (and sometimes enclosed) quartzite. Dip is hard to make out. The layered structure of the quartzite is not always apparent. Where observed, however, in this area the dips

*See Dr. O'Hara's paper, p. 17.


N
W
E
S
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YELLOW BOY
CHILKOOT No. 4
CHILKOOT No. 3
CHILKOOT No. 2
CHILKOOT No. 1
MOZAMBIQUE
DETROIT No. 3
DETROIT No. 2
DETROIT No. 1
DETROIT
HOLDOOT
PARRISH
MAP OF
CHILKOOT GOLD MINING DISTRICT
NEAR CUSTER SO. DAK.
GEOLOGY BY F.E ROCKWELL
STUDENTS' SURVEY SEPT. 1898
SCALE = 1/3600
FEET
GRANITE
QUARTZITE

are prevailingly south and southeast,—away from the Harney Peak granite masses. I have also noted a few westerly dips.* Such changing dip is of course expected in so shattered a region.

The position of the quartz veins are highly inclined. Thus they appear in the Chilkoot, in the Sunrise (a claim just north of those mapped) and in two of the Detroit openings. But in another Detroit opening appears a flat lying mass of quartz about 8 inches thick.

Development.—Development has nowhere proceeded beyond 40 feet in depth. In the Chilkoot this maximum depth is obtained by driving in a side hill a 60 foot tunnel to meet the vein and then sinking at the end of this tunnel. The Detroit openings are not over 8 feet in depth. The Sunrise, just west of the area mapped has a 20 foot shaft. Thus as regards mining the country is in its infancy.

Construction of the Map.—To Mr. M. N. Bolles and to Mr. F. E. Rockwell, students of the School of Mines, belongs the credit of the construction of the map. Of the field work, the topography was mostly done by Mr. Bolles and the greater part of the geology by Mr. Rockwell. The map drawing is Mr. Bolles' work.

The topography was sketched on a skeleton of transit and stadia lines,—the fine broken lines of the map. The elevations are calculated from a U. S. Geological Survey reference stake near the southwest corner of the map.

The geology was put in first, on the evidence of outcrops, and second on that of the study of the float. The probable migration of the float and the relative amounts of the two kinds of float, granite and quartzite were both taken into account.

The value of this work to the students engaged was certainly great. It was the grasping and working out in the field of a practical problem.

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*See Dr. O'Hara's paper, p. 23.

III. Notes on Mining Operations Outside the Area Surveyed.

Gold and Lead.—It was the writer's pleasure to see, though not to study an interesting gold property about two miles east of Custer, just off the Custer-Hermosa road. This property is known as the Lizzie Lode. Its special interest lies in the character of the ore, which is blue, hard and siliceous, much resembling the blue siliceous ore of the Northern Hills. If, as now seems probable, it is the blue refractory siliceous ore of Bald Mountain, this occurrence means a great widening of the siliceous ore belt, coming, as it does here, far south on the Algonkian area.

The rich Holy Terror and Keystone mines of Keystone are perhaps the most interesting, as they are at present the most important gold mines of the Southern Hills. They demand, however, more detailed notice than can be given here, and would furnish by themselves material for another paper.

Mention can merely be made of the writer's visit to the mines and mills of these properties, when by the courtesy of Mr. J. J. Fayel, then superintendent, an underground trip was made through the Holy Terror. It is a pleasure to see mines and mills like these, well equipped and managed in a thoroughly businesslike way.

In the vicinity of Keystone are many other gold properties in various stages of development, but opportunity was not offered to carefully study any of them. The Bismarck should, however, be mentioned as at present being most actively developed. Some notes may also be given in regard to the Bullion, which besides the Holy Terror—Keystone property, was the only Keystone mine visited.

Here is found a large body of low grade ore developed by an open cut, and two tunnels with cross cuts. The open cut is in the hill crest and measures about 350 feet in length, 50 feet in width and 30 feet in depth. Below this cut, one tunnel 300 feet in length is driven into the hillside to tap the ore body at a depth of 175 feet. 200 feet from the mouth of this tunnel a cross cut

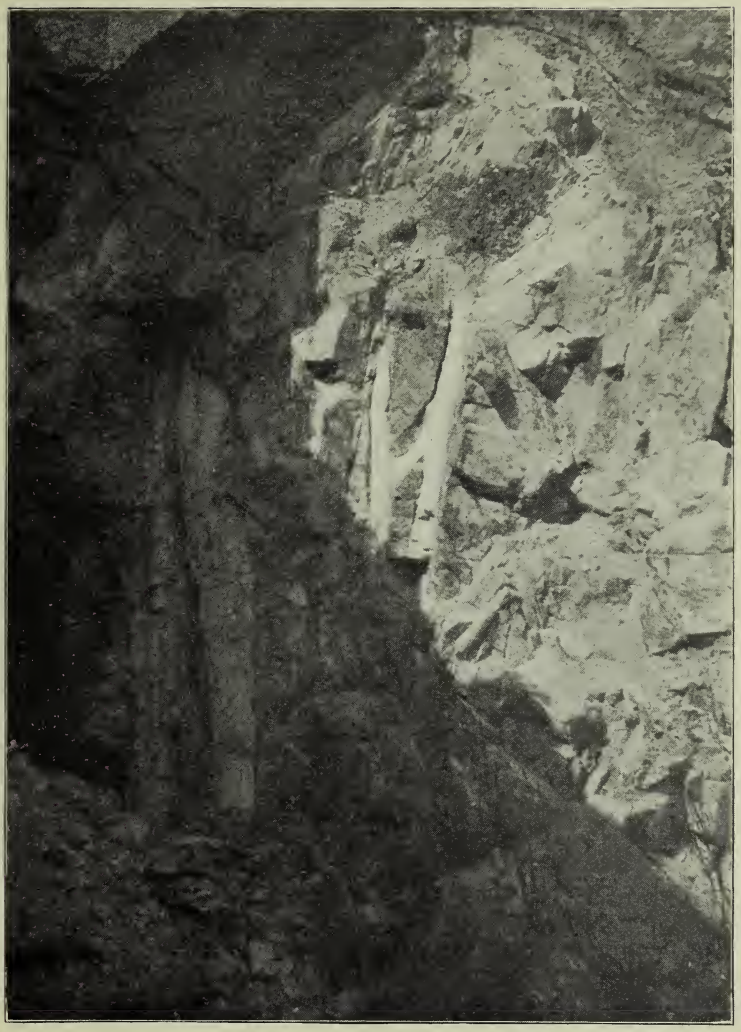

FIGURE 10. SPODUMENE CRYSTALS, ETTA TIN MINE.

of 25 feet is made to disclose the width of the ore body. A second tunnel 320 feet in length has been driven at a lower level in order to tap the ore body at a depth of 400 feet. This tunnel requires about 300 feet more drifting to reach the ore. 230 feet from its mouth is a cross cut disclosing ore.

At Spokane an interesting visit was made to the galena mine of the Crown Hill Company. At the time of the visit, a hundred foot shaft with about eighty feet of drift to the east and twenty-five to the west was to be seen. Since then the company has sunk fifty feet in ore and foot wall. A body of ore several feet in width is reported as disclosed by this sinking. At the bottom of the shaft a water fissure appeared, delaying work until steam pumps could be introduced.

This ore is argentiferous and auriferous. It is said in regard to its silver content, to preserve the rule that the silver runs half as many ounces per ton as the per cent of lead.

The Crown Hill Company is at present making an experimental run of ore in the concentrating plant of the Glendale Tin Co., about two miles from the Spokane mine. The ore concentrated, is that of old dumps made since the beginning of the development of the mine. The concentration is made by means of a Wilfley table, and is reported as a complete success. The table separates the minerals as desired, giving three separate products, galena, iron pyrites and tailings. The capacity of the mill with only one table and inefficient rolls, is twenty tons daily.

From the Spokane mine twenty-four carloads of hand-picked high-grade galena and one carload of concentrates have been shipped.

Reports have recently been made of a new galena vein at Hayward. Much interest attaches itself to the development of the Spokane and other lead properties of the Hills, since an abundant supply of lead ore means value, not only in the lead, gold and silver which it may contain, but also in its service as a collector of the precious metals in the smelting of dry ores.

Graphite, Mica and Spodumene.—Graphite and mica

have to some extent been mined in the vicinity of Custer. The graphite has been found valuable as facing for iron founder's moulds. The mica has been used in dynamo manufacture. An occurrence of graphite was seen on French Creek where the graphite appeared in rather granular masses of varying purity up to a foot in thickness in close grained quartzite.

A mica mine about two miles west of Custer was visited. Here in a 30 foot shallow cut in pegmatite, about 40 mica books of from 8 to 12 inches in size were exposed.

A new experiment in mining in the Southern Hills has been the recent breaking down and shipment of a carload of spodumene from the famous occurrence in the Etta tin mine.

Dr. Carpenter mentions these spodumenes of the Etta in his "Mineral Resources of the Black Hills," page 136 of the "Preliminary Report of the Dakota School of Mines." He here describes their perfect shape and wonderful size, giving one a length of 35 feet. At the time of our visit none of that length were to be observed, but the accompanying half tones, (Figures 10 and 11) give some idea of the shape, size and manner of occurrence of the crystals seen by us. Unfortunately in the production of the copper plate, the man's figure which shows the scale in Figure 10 failed to come out clearly. A careful inspection will however disclose it.

This experimental carload of spodumene was mined for Reinbold & Co. of Omaha by Mr. M. Dodge of Rapid City. Thirty tons were taken out. The mining of this material spoiled of course all those large crystals previously exposed. Fortunately our photographs were taken before the mining operations commenced.

The expenses of mining on this experimental lot were $6.00 per ton. The spodumene proved about one-fifteenth of the material mined. The writer has as yet been unable to obtain information in regard to the chemical analysis of the material shipped, and the exact use to be made of it. He is indebted to Mr. M. Dodge for data in regard to mining and shipment.